CNM.

June 2, 1965

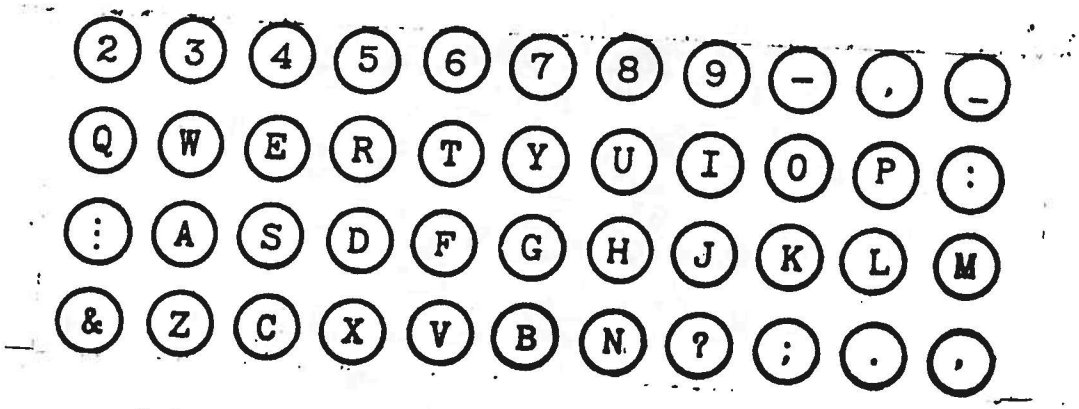
To: WORKING GROUP X4-A9.1

From: J. B. Booth

Subject: PROPOSED ASSIGNMENT OF THE ASCII GRAPHICS

BACKGROUND

The present manual typewriter keyboard arrangement evolved from the arrangement illustrated in Figure 1, which appeared in the first typewriter catalogue of Remington. By 1876, the arrangement of the alphabet had



Original Typewriter Keyboard Arrangement (1874)

Figure 1

Sholes

settled to that which is common on all typewriters today. Prior to 1900 keyboards contained 42 keys (and the associated typing mechanism contained 84 graphics) - the same 42 key positions available on typewriters today. The evolution of the graphics assigned to the right of the alphabet and above the digits is illustrated in Table 1 in which it is shown that the present "standard" manual typewriter keyboard arrangement dates back to 1929. The specific reasons for the assignments were not available in the limited research which I conducted. Improved assignments of these symbols have been suggested by proponents of improved keyboard arrangements. These proposals, however, suggest a radical departure from the present assignments coupled with a radical shifting of the alphabet.

Function keys such as backspace, tabulation, margin release, and others were added outside of this basic 42 key field. The electric typewriter employed the same 42 key field, but a number of graphics, above the digits and to the right of the alphabet, were reassigned in the first electric typewriter as shown in Table 1. Initially, typewriter manufacturers, with the exception of Electromatic, provided electric typewriters with a keyboard arrangement identical to the manual typewriter. By 1956, the present electric typewriter keyboard arrangement had become a "standard" for electric typewriters.

The keyboard of teleprinters generally followed the typewriter keyboard arrangement. There were certain restrictions, however, since the machine was limited to 52 graphics which included the alphabet, the digits and a maximum of 16 symbols. To accommodate more than the alphabet, the teleprinter employed a mode shift to obtain the digits and the symbols, resulting in an alpha character having the same code as a digit or a symbol. To minimize the number of keys, the alpha character and its associated graphic were shown on the same keytop. Figure 2 illustrates one such arrangement. In this specific arrangement 15 additional symbols and one control (BELL) were provided.

A variation of this arrangement was one in which the digits were placed on a fourth row above the alphabet as illustrated in Figure 3; with this arrangement the top row was locked when the machine was in the "Letters" mode and the third row (QWERT...) was locked in the "Figures" mode.

Six of the teleprinter codes have the same meaning in both the "Figures" and "Letters" mode, viz., SPACE, CARRIAGE RETURN, LINE FEED, BLANK, LETTERS SHIFT and FIGURES SHIFT. Two of these - CARRIAGE RETURN and LINE FEED - are functions which were not necessary on a manual typewriter, since the carriage was returned by hand and in the process the platen was rotated to the next line. Because of the restricted graphic set of a teleprinter and because of the frequent use of the CARRIAGE RETURN and LINE FEED, these keys were placed in a convenient position to be touch-typed.

ASSIGNMENT OF GRAPHICS

The following factors enter into a consideration of the assignment of graphics for an ASCII keyboard arrangement:

1. Present typewriter keyboard arrangements
   - 1.1 Manual typewriter
   - 1.2 Electric typewriter
2. Position in ASCII, i.e. code assignment
3. Frequency of usage
   - 3.1 Graphics
   - 3.2 Functions

Regarding factor 1, the present manual typewriter keyboard arrangement has been in existence since 1929. The introduction of the electric typewriter in 1932 resulted in the reassignment of the quotation marks ("), commercial at (@), underline (_), cent sign (¢), apostrophe ('), and asterisk (*). This arrangement became common for electric typewriters by 1956; the requirements of an electric typewriter dictated the above reassignments.

Factor 2 relates to the "normal" ASCII pairing of symbols as illustrated in Table 2.

The only frequency tables which I have been able to uncover, to date, are those shown in tabular form in Table 3. These tables, with the exception of Roy T. Griffith's, dealt only with the alphabet. Roy T. Griffith included the symbols in his considerations of the order of frequency of usage.

The pairing of symbols, as illustrated in Table 2, results in some graphic assignments which deviate from existing manual and electric typewriter keyboard arrangements - just as the development of the electric typewriter dictated certain deviations from the then existing manual typewriter keyboard arrangement. This pairing results in the following assignments which seem to be acceptable to the majority:

Key Position	Symbol	
	Unshift Mode	Shift Mode
5	1	!
6	2	"
7	3	#
8	4	$
9	5	%
10	6	&
11	7	'
12	8	(
13	9	)
14	0	
54	;	+
73	,	
74	.	
75	/	?

The symbols which remain to be assigned are as follows:

asterisk (*)
hyphen (-)
colon (:)
greater than (>)
less than (<)
underline (__)
commercial at (@)
equals (=)
grave accent (`)
left and right brackets ([ ])
tilde (~)
circumflex (^)
left and right braces ({ })
overline (¯)
vertical bar (|)

In applying the three factors, listed above, to the placement of the above graphics the following results:

1. Position on present typewriter keyboard arrangements
   1.1 Manual typewriter
   The above symbols appear on the following keytops of present manual typewriters:

Symbol	Keytop	
	Number	Position
*	15	Top
- (hyphen)	15	Bottom
:	54	Top
__ (underline)	10	Top
@	55	Top
=	16	Bottom (44 keyfield)

1.2 Electric typewriter

The above symbols appear on the following keytops on present electric typewriters:

Symbol	Keytop Number	Keytop Position
*	12	Top
- (hyphen)	15	Bottom
:	54	Top
_ (underline)	15	Top
@	6	Top
=	16	Bottom (44 keyfield)

The hyphen, colon and equals sign occupy the same position on both manual and electric typewriters.

2. Pairing

The "normal" ASCII pairing is as follows:

asterisks with colon
hyphen with equals
commercial at with grave accent
left bracket with left brace
right bracket with right brace
tilde with overline
circumflex with vertical bar

The underline does not pair with a graphic and the greater and less than would "normally" pair with the period and comma respectively.

3. Frequency

3.1 Graphics

According to Mr. R. T. Griffith, of the above symbols, the hyphen (-) is used most frequently followed by the colon (:); he does not provide an order for the remaining symbols.

3.2 It is my opinion that the CARRIAGE RETURN and LINE FEED functions will be used more frequently than any other ASCII controls, and also that they will be used more frequently than many (if not most) of the symbols.

Given the above factors, a proposed assignment of the above unassigned symbols may be developed. The hyphen (-) is located on key 15 (lower position) on typewriters. However, the hyphen, according to Mr. Griffith, is used more frequently than the colon and, therefore, should be closer to the home keys, e.g. on key 35 or 55. Although the asterisk (*), which has a "normal" (ASCII) pairing with the colon(:), is used more frequently than the equals sign (=) which, in turn, has a "normal" (ASCII) pairing with the hyphen (-), it would appear that, considering frequency of usage along, the hyphen/equals symbols would be placed on key 55 and colon/asterisk on key 35. However, when considering the controls CARRIAGE RETURN and LINE FEED, the assignment of a graphic to key 55 is subject to a more critical review.

As noted previously, by 1900 the typewriter contained 42 printing keys, the 42 keyfield defined in the working documents of X4-A9.1. Also, as noted previously, the teleprinter had a smaller graphic set and in addition required controls and, therefore, keys to return the carriage and feed the paper - a requirement which was satisfied by a carriage arm on the typewriter.

The CARRIAGE RETURN and LINE FEED keys were placed on the keyboard of a teleprinter so that the operator would strike the sequence CARRIAGE RETURN-LINE FEED at the end of each line. This sequence was necessary to allow time for the carriage to return (during the line feed function) before transmission of the next graphic. In fact, it has been the practice in the Bell System 3-row TWX service to transmit the sequence CARRIAGE RETURN-LINE FEED-LETTERS to insure that the carriage had returned before transmitting the next graphic.

When electric typewriters were introduced, a key was provided to return the carriage and to advance the line; this key was added to the right of the 42 printing keys and was made large enough so that the operator could strike it easily.

The ISO 7-bit code, which is the international version of ASCII, contains a note which reads as follows:

> "For equipment which uses a single control for combined carriage return and line feed operation, the function FE_2 (LF) will have the meaning New Line (NL). This requires agreement between the sender and the recipient of the data."

Although ASCII doesnot carry this note, machines implementing ASCII could be so arranged and so operate with agreement between the sender and the recipient of the data. However, for general information interchange, separate carriage return and line feed controls would be required.

That which is required, therefore, is a specification which allows both of the above conditions to exist. If the output from an ASCII keyboard were never recorded in media, for subsequent relay, or if receiving page devices could return the carriage in one character cycle, it would not be necessary to have a time delay for the CARRIAGE RETURN function. However, such is not the case, and, therefore, some delay is necessary after CARRIAGE RETURN.

This delay could be accomplished by means of a feedback circuit, a transmitter time out or other equivalent means. However, that which has been found to be the most economical is to transmit the two functions CARRIAGE RETURN-LINE FEED in that sequence. Any proposed ASCII keyboard arrangement should allow for the placement of these critical function keys within the touch-type field and, therefore, key positions 55 and 56 should be reserved for function keys.

Key positions 15 and 35 are now candidates for the hyphen/equals combination and the colon/asterisk. It would appear that the previous position of Working Group X4-A9.1 in which the hyphen/equals were assigned to key position 15 is the most logical, since this is the position the hyphen occupies on both the manual and electric typewriters. The colon/asterisk combination would than be assigned to key position 35.

Of the remaining symbols, the underline (_) and the commercial at (@) are available on typewriters. Key positions 16 and 36 would be the candidate positions for these symbols. The underline is the more frequently used of the two and, therefore, possibly should be assigned to key position 36, which is slightly closer to the home keys than key position 16. However, the previous position of the Working Group, in which the underline was assigned to key position 16, seems more logical, since the underline would be adjacent to the position it now occupies on an electric typewriter. The commercial at (@) would than be assigned to key position 36.

The assignments to this point have occupied 46 keys of the expanded typewriter key field (key positions 55 and 56 reserved for functions). It may be desirable to assign the bracket/brace combinations to key positions 17 and 37 to allow their inclusion in a 48 key keyfield and to place the overline/tilde and vertical bar/circumflex in key positions 18 and 38 respectively.

Regarding the greater than (>) and less than (<), I favor the traditional typewriter approach because of the human factors. A proposed standard keyboard arrangement could contain a note specifying that an acceptable deviation is to place the greater than and less than in the upper positions of key positions 74 and 73 respectively. Figure 4 illustrates the proposed keyboard arrangement.

TABLE

EVOLUTION OF TYPEWRITER GRAPHICS

Manual Typewriter

Key Position

YEAR	5	14	15	16	35	55	73	74	75
1896		)	o		+	¢	?	.	§
		-	*		=	¢	,	/	!
1905		)	*		¼		?	.	¾
		0	-		½		,	.	/
1908			¾				,		?
			-				,		/
1925			*				?		¾
			-				,		/
1929							,		?
							,		/
1952	¶			+					
	§			=					
1955	!								
	1								

Electric Typewriter

Key Position

YEAR	5	6	10	12	15	16	55	73	75
1932		@	¢	*	—		"	,	?
		2	6	8	-		'	,	/
1936		"	—	'	*		@	,	?
		2	6	8	-		¢	,	/
1948		"	*	'	—		@	?	¾
		2	6	8	-		¢	,	/
1950		"	*	'			@	,	?
		2	6	8			¢	,	/
1955		"	*	'		+	@		
		2	6	8		=	¢		
1956	!	@	¢	*			"		
	1	2	6	8			'		

See Note (1)

NOTE: (1) Original electric keyboard (1932) of Electromatic (now IBM) conformed to present arrangement. Variations shown were found on machines manufactured by other manufacturers.

Information courtesy of Remington Office Machines Division of Sperry Rand Corporation, Olivetti Underwood Corporation and IBM

TABLE 2

KEYTOP PAIRINGS WHICH RESULT IF

A SINGLE ASCII BIT IS INVERTED

Keytop Symbol		ASCII Bit Inverted
Lower	Upper	
1	!	b_5(1 to 0)
2	"	
3	#	
4	$	
5	%	
6	&	
7	'	
8	(	
9	)	
:	*	
;	+	
,	<	b_5(0 to 1)
-	=	
.	>	
/	?	
@	`	b_6(1 to 0)
¬	~	
|	^	
[	{	b_6(0 to 1)
]	}	

TABLE 3

FREQUENCY OF USAGE OF ALPHABET

Frequency	Bruce Bliven	Roy T. Griffith	Roy E. Hoke
1	E		
2	T		
3	A		
4	O		I
5	S	N	R
6	I		O
7	N	S	
8	R		N
9	H		L
10	L		D
11	D		H
12	C		
13	U		
14	M		
15	Y	F	P
16	B	Y	G
17	P	W	F
18	W	G	Y
19	F	P	W
20	G	B	
21	V		
22	K		
23	J	X	
24	X	J	
25	Q		
26	Z		

Suggested Order
E
T
A
O
N
I
S
R
H
L
D
C
U
M
Y
P
F
W
G
B
V
K
X
J
Q
Z

Roy T. Griffith
,
.
-
n
'
0 (zero)
1 (one)
2
;
?
:

TELETYPEWRITER KEYBOARD ARRANGEMENT

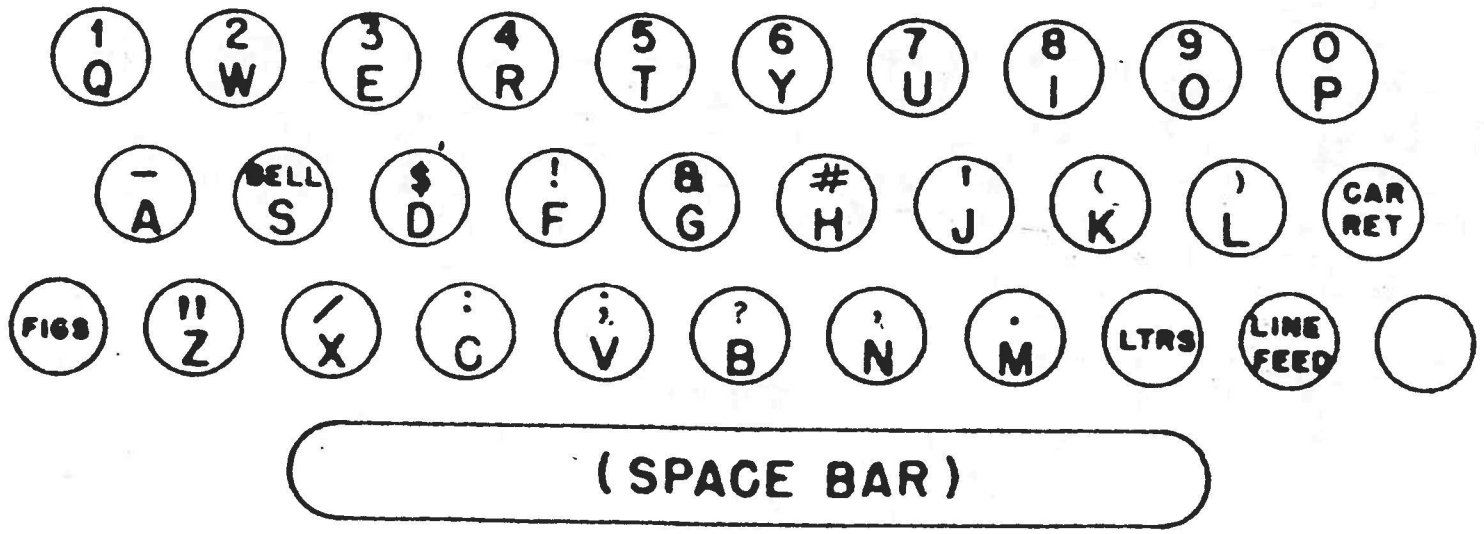
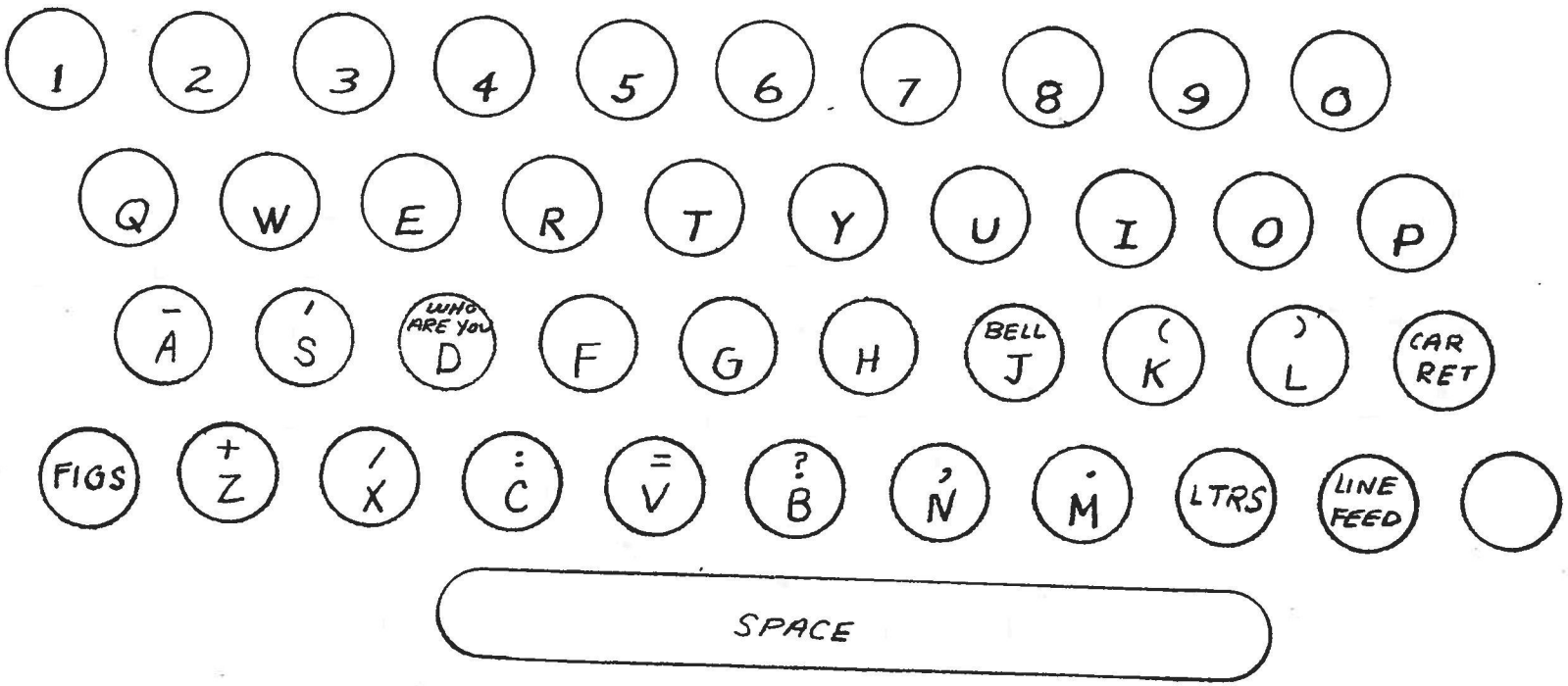
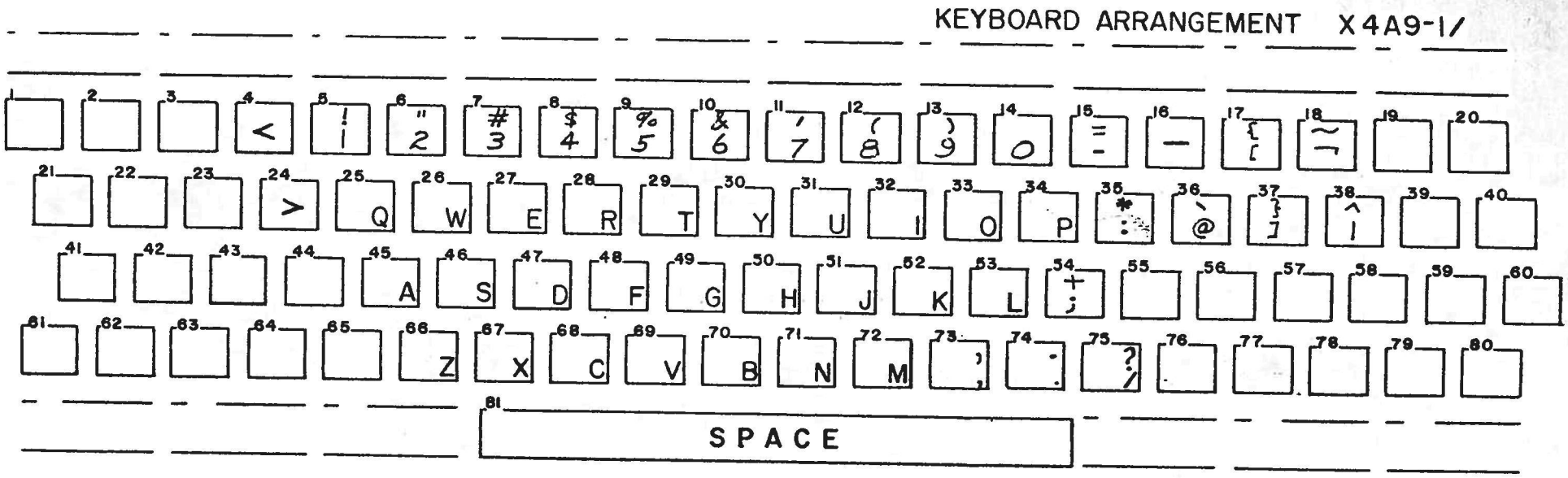


FIGURE 2



FOUR ROW TELEPRINTER
KEYBOARD ARRANGEMENT

FIGURE 3



PROPOSED ASCII KEYBOARD ARRANGEMENT

FIGURE 4